Elias Metschnikoff, Director of the Paris Pasteur Institute, Prof. W. H. Flower, C.B., F.R.S., and Mr. W. E. H. Lecky.

Delegates from the seventh International Congress of Hygiene and Demography will be received by the Vice-Chancellor in the Senate House on Saturday, August 15.

The Museums Association hold their annual meeting in July in the buildings lately erected for the departments of Anatomy and Physiology.

Prof. Foster is appointed by the University a Member of Council of the Marine Biological Association.

The reference to the Syndicate on the question of Greek in the Previous Examination has been enlarged to include Latin also, and will be decided on by the Senate early in the October term. An animated discussion on the question took place in the Arts School, in which the claims of modern (non-classical) education for consideration by the University were strongly put forward by men of the highest classical distinction.

Mr. J. N. Keynes, the Secretary for the Local Examinations, has been approved for the degree of Doctor in Science.

An election to an Isaac Newton Studentship will take place in October. The value is £200 a year for three years from April 15, 1891. Candidates are to send their names and testimonials to the Vice-Chancellor between October 1 and 10.

It is proposed to affiliate the University to the University of Adelaide, South Australia.

The General Board of Studies propose that Dr. Ruhemann, hitherto Assistant to Prof. Dewar, shall be appointed a University Lecturer in Organic Chemistry.

A room in the new Physiological Laboratory is to be set aside for Psychophysics, and a grant of £50 for instruments is recommended by the General Board.

The Annual Report of the University Observatory contains a good record of work done and in progress. Prof. Adams is to be congratulated on the satisfactory way in which, notwithstanding his long and severe illness, the Observatory has been conducted.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 14.—"On the Theory of Electrodynamics." By J. Larmor, Fellow of St. John's College, Cambridge. Communicated by Prof. J. J. Thomson, F.R.S.

The electrical ideas of Clerk Maxwell, which were cultivated partly in relation to mechanical models of electrodynamic action, led him to the general principle that electrical currents always flow round complete circuits.

When this principle of circuital currents is postulated, the theory of electrodynamics is reduced to the Ampère-Neumann theory of complete circuits, of which the truth has been fully established. It leads, as shown by Maxwell, to the propagation of electrical action in dielectric media by waves of transverse electric displacement, which have the intimate relations to waves of light that are now well known.

The problem of determining how far these remarkable conclusions will still hold good when a more general view of the nature of dielectric polarization is assumed was considered by von Helmholtz in a series of memoirs.

The most general conception of the polarization of a medium which has been formed is the Poisson theory of magnetization. The magnetized element, whether actually produced by the orientation of polar molecules, or otherwise, may be mathematically considered to be formed by the displacement of a quantity of ideal magnetic matter from its negative to its positive pole, thereby producing defect at the one end, and excess at the other end. The element is defined magnetically by its moment, which is the product of the displaced quantity and the distance through which it is displaced. The displacement per unit volume, measured by this product, is equal to the magnetic moment per unit volume, whether the magnetized molecules fill up the whole of that volume or are a system of discrete particles with unoccupied space between them.

In the electric analogue we replace ideal magnetic matter by ideal electric matter; the displacement thus measured constitutes the electric displacement, and its rate of change per unit time represents the displacement current in the dielectric. We have to consider whether a displacement current of this type suffices to make all electric currents circuital; and it will be sufficient and convenient to examine the case of a condenser which is charged through a wire connecting its two plates. In the first place, this notion of electric displacement leads to the same distribution of potential between the plates as the ordinary one, adopted by Maxwell; for in the theory of induced magnetism there occurs a vector quantity of circuital character, the magnetic induction of Maxwell, of which the components are $-\mu(dV/dx)$, $-\mu(dV/dy)$, $-\mu(dV/dz)$, and which, therefore, leads to the characteristic equation of the potential

$$\frac{d}{dx}\left(\mu\frac{dV}{dx}\right)+\frac{d}{dy}\left(\mu\frac{dV}{dy}\right)+\frac{d}{dz}\left(\mu\frac{dV}{dz}\right)=0,$$

corresponding to the one given above. If the displacement in the dielectric is $-\kappa(dV/dx)$, $-\kappa(dV/dy)$, $-\kappa(dV/dz)$, then

$$\mu = 1 + 4\pi\kappa.$$

The displacement in a unit cube may, of course, be considered as a displacement across the opposite faces of the cube.

Now, considering the case of a plane condenser, let F be the electric force in the dielectric between the plates; then the displacement is κF. Let σ be the surface density of the charge conducted to a plate; then the effective electrification along that plate will be of surface density $\sigma' = \sigma - \kappa F$; therefore, by Coulomb's principle,

$$\begin{aligned} F &= 4\pi\sigma' \\ &= 4\pi(\sigma - \kappa F); \end{aligned}$$

so that

$$\sigma = \frac{\mu}{4\pi}F = \kappa F + \frac{1}{4\pi}F.$$

Thus the current is not circuital, but there is an excess of the surface density conducted to the surface over the displacement current from the surface, which is equal to $F/4\pi$.

The specific inductive capacity, as determined by static experiments on capacity, is here measured by μ, the coefficient in the expression for σ.

In addition to this discontinuity at the face of a condenser plate, the induction in the mass of the dielectric will not be circuital unless the electric force is itself circuital, which it is not in the general form of the electrodynamic theory.

The most general type of electrodynamic relations which is consistent with the established theory of complete circuits, is discussed on the basis of von Helmholtz's work, but with avoidance of certain restricting conditions introduced by him, the chief conclusion being as follows:

In a complete circuit the one thing essential to the established theory is that the electric force integrated round the circuit should be equal to the time rate of change of the magnetic induction through it, and, therefore, have an ascertainable value, though its distribution round the circuit is a subject of hypothesis. The conclusion that waves of transverse displacement will be propagated in a dielectric with velocity $K_1^{-\frac{1}{2}}$ will hold good if we assume any form whatever for the electric force which does not violate this one relation, and also assume an electrostatic polarization of the medium, equal at each point to the electric force multiplied by a constant $K_1/4\pi$.

The increased generality which can be imparted to the theory merely leads to various modes of propagation of a condensational wave.

If K_2 denote the specific inductive capacity of the medium, measured in static units, this polarization constant K_1 is equal to $K_2 - 1$; and the velocity of the transverse waves is the ratio of the electric units of quantity in a medium of unit inductive capacity multiplied by the static value of $K_1^{-\frac{1}{2}}$. The correspondence of the refractive index for the simpler media with $K_2^{-\frac{1}{2}}$, as well as direct measures of the relative velocities of electric waves in other media, give for the value of this velocity the same ratio multiplied by $K_2^{-\frac{1}{2}}$. These values can be reconciled only by the limiting form of the theory of polarization which is equivalent to Maxwell's theory.

May 28.—"On the Anatomy and Physiology of *Protopterus annectens.*" By W. N. Parker, Ph.D., F.Z.S., Professor of Biology in University College, Cardiff. Communicated by W. H. Flower, F.R.S.

The work which has resulted in the present paper was begun in Freiburg in the summer of 1888, when the author was fortunate enough, owing to the generosity of Prof. Wiedersheim, to obtain a number of fresh specimens for examination. As so many interesting points presented themselves at an early stage in the research, a short preliminary notice, without illustrations, was published in the following autumn (*Berichte d. Naturforsch. Gesellschaft zu Freiburg i. Br.*, vol. iv. 1888; see also NATURE, vol. xxxix. p. 19) This notice merely forms the basis of the present paper, in which the whole subject has been worked out in greater detail. A number of new facts are recorded, some of the author's earlier conclusions modified, and the paper illustrated with 11 plates containing 71 figures.

With the exception of certain special details, the structure of the skeleton and of the nervous and muscular systems are not described, the paper consisting mainly of an account of other organs which have not received so much attention from previous observers, and of a comparison of *Protopterus* with the other genera of Dipnoi, so far as their structure is known, as well as with other Ichthyopsida.

A number of details with regard to the habits of *Protopterus* in captivity are given.

The paired extremities show no connection with the cheiropterygium, and, in spite of their considerable nerve-supply, are evidently greatly degenerated structures as regards their free portions. Sensory organs are not present on them, and they therefore cannot have a tactile function. Their distal ends, like the apex of the tail, are very variable, and can undoubtedly be reproduced when lost by accident. The tail is almost certainly not primarily diphycercal, and shows signs of a possible origin from a heterocercal form.

The epidermis on the whole most nearly resembles that of Perennibranchiate Amphibians, and gives rise to simple multicellular glands, as well as to very numerous closely-packed goblet-cells, which produce the gluey secretion as well as the main substance of the capsule which surrounds the animal during the torpid state.

The integumentary sense-organs are similar to those of fishes and larval Amphibians. The relations of the sensory organs of the trunk are similar to those seen in young stages of Fishes and in Amphibian larvæ, while in the case of the head they resemble those which are typical for adult Fishes. End-buds, similar in structure to the taste-buds of Fishes and Amphibians, are present on the tongue and oral epithelium.

As regards its general structure, the olfactory organ most nearly resembles that of Elasmobranchs, but the presence of posterior nostrils raises it to a higher level. The position of the anterior nostrils beneath the upper lip is probably to be accounted for as an adaptation in connection with the torpid state. Four straight and two oblique muscles are present. The sclerotic is fibrous in young animals, and islands of cartilage first appear at the points of insertion of eye-muscles, and then gradually extend so as to chondrify the whole. The eye resembles that of Amphibians; a *processus falciformis* and *campanula Halleri* are absent, and no ciliary muscles were observed, though possibly present; almost all the pigment of the eye is ectodermic.

No specialized glands are present in connection with the greatly folded epithelium of the oral cavity. The lips contain no muscles. The tongue, as well as the palate, is covered with blunt conical papillæ, on which the taste-buds are situated. A horny cap is developed over each tooth from the overlying epithelium, which apparently becomes cut through by the sharp edges and points of the teeth, and which probably corresponds to the *cuticula dentis*. The thyroid and thymus are described.

A ventral, as well as a fenestrated dorsal, mesentery is present supporting the intestine. The author compares the so-called urinary bladder ("cloacal cæcum") with the "processus digitiformis" of Elasmobranchs. A spleen and pancreas are present, embedded in the thin walls of the stomach, and extending on to the proximal part of the intestine; they are covered externally by sparse muscular fibres as well as by the peritoneum. The relations of the pancreas therefore most nearly resemble those met with in Ganoids and certain Teleosteans. The pancreas is deeply pigmented, and its ducts open into the bile-duct. The pigmented walls of the intestine and the spiral valve are very thick, owing to the abundance of lymphoid tissue contained within them. With the exception of the bursa entiana, the internal walls of which are raised up into a number of deeply pigmented oblique folds, the whole of the mucous membrane of the stomach and intestine is perfectly smooth, and there is no indication of any differentiated gastric or intestinal glands.

Cilia are present on the epithelium throughout the stomach and intestine. A layer of small-celled lymphoid tissue directly underlies the epithelium. In the spleen and lymphoid organs of the intestine two kinds of tissue are present. Large migratory cells are present in both kinds of tissue, many of which inclose yellowish granules. Gradations between these and rounded cells of a deeper yellow or brown colour can apparently be made out, and cells appearing to be intermediate forms between these and the ordinary black, branched pigment cells can also be seen. It seems probable that the yellow granules mentioned above are due to the disintegration of red corpuscles, which are ingested by leucocytes, and then undergo some change, whereby the latter gradually pass into the condition of black pigment cells, which migrate through the epithelium, and are so got rid of. The muscular layers are very thin.

The question as to the mode of digestion and absorption of the food in *Protopterus* is discussed.

The branchial apparatus shows signs of considerable reduction. The pulmonary apparatus, on the whole, more nearly resembles the air-bladder and its duct of certain Ganoids than the lungs and laryngo-tracheal chamber of Amphibians. The pulmonary branches of the vague cross one another at the base of the lungs.

The blood is remarkable for the large size of its elements, which is only exceeded in the case of *Proteus* and *Siren*, as well as for the large proportion of white corpuscles in comparison with the red ones. Two forms of the former are described. The chief points of interest with regard to the blood-vessels are: (1) the paired pulmonary artery, the left supplying the ventral, and the right the dorsal, aspect of the lungs; (2) the single post-caval and persistent left posterior cardinal vein; and (3) the single caudal vein, giving rise to a right and a left renal portal.

No external sexual differences could be observed, and amongst the specimens examined, females were the more abundant. The urino-genital organs are surrounded by masses of tissue resembling the large-celled lymphoid tissue of the gut, but differing from the latter in becoming largely converted into adipose tissue. The kidneys probably represent the mesonephros, and their duct the Wolffian duct; nephrostomes are absent.

In unripe males, delicate Müllerian ducts are present. The sperm is conducted to the exterior by a duct, which is probably formed in connection with the testis, quite independently of the excretory apparatus. The seminal tubules are directly connected with it, and it opens into the base of the Müllerian duct, the rest of which apparently aborts completely. Unlike most of the tissue elements, which are very large, and closely resemble those of the Amphibia, the spermatozoa are very minute, and are remarkable in possessing *two* vibratile flagella attached to the carrot-shaped "head." The generative organs of the female bear a striking resemblance to those of Amphibians. The oviduct corresponds to the Müllerian duct; the epithelium covering its internal folds shows signs of degeneration similar to those which have recently been described amongst Urodeles.

An account of the mode of life of *Protopterus* during the torpid period is given. The cocoon is provided with a "lid," perforated by a hollow funnel-shaped tube, which passes between the lips of the animal, and thus forms a passage for the respiratory current. The source of nutriment during the summer sleep lies in the adipose tissue in connection with the gonads and kidneys and alongside the notochord in the tail, as well as in the lateral muscles, some of which, especially in the caudal region, undergo a granular degeneration. Very probably the latter is the precursor of the fatty degeneration, and, in all probability, leucocytes are the active transporting agents of the degenerated material. This assumption would help to explain the large development of lymphoid tissue in the body of the animal.

The systematic position of the Dipnoi is briefly discussed in the light of the new facts brought forward in the present paper. Although the Dipnoi present many points of resemblance to Fishes on the one hand, and to the lower Amphibians on the other, their connection with any living forms of either class is probably a very distant one, and it is inadvisable to classify them amongst the Fishes. Owing to the absence of ontological evidence, and to the incompleteness of our knowledge of the palæontological history of the Dipnoi, it is impossible to construct a genealogical tree which will show, with any approach to accuracy, the probable connection between them and other Ichthyopsidan types. The most that can be said at present, with anything like certainty, is that the Dipnoi are the isolated survivors of an exceedingly ancient group, which was probably related to the ancestors of existing Fishes and Amphibians. Amongst the former, the connection seems to be closest to the

Elasmobranchs, more particularly to the Chimæroids on the one hand, and to such an ancient Selachian type as *Chlamydoselache* on the other; but, at the same time, the Ganoids probably arose from the common ancestral stock not very far off. Though retaining many primitive characters, the Dipnoi, and more especially *Protopterus* and *Lepidosiren*, are in some respects highly specialized, the specialization being largely due to a change of habit.

"Method of Indexing Finger Marks." By Francis Galton, F.R.S.

Sufficient proof was adduced by me in a memoir read November 27, 1890, before the Royal Society (Phil. Trans., B, 1891), of the extraordinary persistence of the papillary ridges on the inner surface of the hands throughout life. It was shown that the impression in ink upon paper of each finger tip, contained on the average from twenty-five to thirty distinct points of reference, every one of which, with the rarest exception, appeared to be absolutely persistent. Consequently that it was possible to affirm with practical certainty whether or no any two submitted impressions were made by the fingers of the same person.

In the present memoir I shall explain the way in which finger prints may be indexed and referred to after the fashion of a dictionary, and on the same general principle as that devised by A. Bertillon with respect to anthropometric measures, whose ingenious method is now in regular use on a very large scale in the criminal administration of France and elsewhere. I desire to show how vastly the practical efficiency of any such method as that of A. Bertillon admits of being increased by taking finger prints into account in the way to be described.

It must not, however, be supposed that the use of indexing finger marks is limited to the above purpose, the power of doing so being equally needed for racial and hereditary inquiries. I do not dwell upon these applications now, simply because I am engaged in making them, and the results are not yet ready to be published. I ought, however, to mention that a great increase of experience has fully confirmed my earlier views, that finger marks are singularly appropriate subjects of anthropometric study owing to many distinct reasons. The impressions are easily to be made by anyone who has the proper appliances at hand. They are as durable as any other printed matter, and they occupy very little space. The patterns are usually sharp and clear, and their *minutiæ* are independent of age and growth. They are necessarily trustworthy, and no reluctance is shown in permitting them to be taken, which can be founded either upon personal vanity or upon an unwillingness to communicate undesirable family peculiarities.

Without caring to dwell on many of my earlier failures to index the finger prints in a satisfactory way, my description shall be confined to that which has proved to be a success. It is based on a small variety of conspicuous differences of pattern in each of many digits, and not upon the numerous minute peculiarities of a single digit. My conclusions are principally based on a study of the impressions of all 10 digits of 289 different persons, but the tables given in the memoir refer only to the first 100 on my list. These are sufficiently numerous to serve as a fair sample of what we might always expect to find, while they are not too cumbrous to print and to discuss in full detail.

Though I have spoken and shall speak only of impressions, it is not really necessary in forming an index to make any impression at all. All the entries that appear in it may be derived directly from the fingers themselves.

I rely, for the purpose of indexing, on the three elementary divisions of primaries, whorls, and loops. They are severally expressed by the numerals 1 and 2, 3 and 4, 5 and 6. The reason of this double numeration is that most of the patterns have a definite axis. Those that are formed by ridges which proceed from only one side of the finger, lie in a sloping direction across its axis, the slope being directed according to the side from which the supply of ridges proceeds. All normal slopes, or those that are (roughly) parallel to a line drawn from the tip of the forefinger to the base of the little finger, as well as all the patterns that have no definite axis, are expressed by the odd numerals, 1, 3, or 5. All abnormal slopes are expressed by the even numerals 2, 4, or 6. It cannot be too strongly insisted that the words right and left are ambiguous, and must not be used here.

The forefingers are the most variable of all the digits in respect to their patterns, their slopes being almost as frequently abnormal as not; the third fingers rank next; the little finger ranks last, as its pattern is a loop in nine cases out of ten. I therefore found it convenient not to index the fingers in their natural order, but so that the sequence of the numerals which express the patterns on the digits should be divided into two groups of three numerals, and two groups of two numerals, as 355, 455, 55, 35. The first group 355 referring to the first, second, and third fingers of the left hand; the second group 455 to the first, second, and third fingers of the right hand; the third group 55 to the thumb and fourth finger of the left hand; the fourth group 35 to the thumb and fourth finger of the right hand. The index is arranged in the numerical sequence of these sets of numbers.

Before translating the patterns into numerals, I find it an excellent plan to draw symbolic pictures of the several patterns in the order in which they appear in the impression, or in the fingers themselves, as the case may be, confining myself to a limited number of symbols [a list of those which have thus far sufficed is given in the memoir; 5 of them are symmetrical symbols, and 9 are tailed and duplicated for the reasons given above, one of each pair being inclined to the right, and the other to the left. The total number of these hieroglyphs is consequently 23]. A little violence has of course to be used now and then, in fitting some unusual pattern to one of these symbols. But we are familiar with such processes in ordinary spelling, where the same letter does duty for different sounds, as *a* in the words *as*, *ask*, *ale*, and *all*. The merits of this process are many. It facilitates a leisurely revision of first determinations; it affords an adequate record of the character of each pattern; it prevents mistakes between normal and abnormal slopes; it prevents confusion when changing the sequence of the entries from the order of the impressions to that used in the index; and, lastly, it affords considerable help to a yet further subdivision of the patterns.

In making a large and complete index, the symbols would, of course, be cast as movable types, and be printed with the letterpress.

It appears from the 100 cases that are printed in the memoir that there were 83 different varieties of index numbers when all 10 digits are used. Consequently the average number of references required to pick out a single well-defined case from among these 100 would be equal to 100 divided by 83—that is, to about 1¼. I do not expect from my own reiterated experiences that there would be much trouble due to transitional cases, after a standard collection of doubtful forms had been collected and numbered, so as to insure that different persons should follow a common standard. I find much uniformity in my own judgment.

Owing to the large effect of correlation, an index based on all the 10 digits is not much superior in efficiency to one that is based on six—namely, upon the first three fingers of both hands. In the 100 different sets there are, as already said, 83 varieties of pattern in the one case, and there are 65 in the other, which roughly accords with the relative efficiency of 5 to 4. It is, therefore, a fair question whether it is worth while to impress all the 10 digits. The chief advantage of doing so is to add to the volume of evidence, and to supply data which mutilation, or bad scars, or obliteration due to some exceptional cause might render of value. The three fingers of both hands are more than twice as useful for an index as those of one hand only; again, the three fingers of one hand are nearly twice as useful as two only. I may mention that for my present inquiries into racial and hereditary patterns I am, for various reasons, dealing only with the first three fingers of the right hand, and slightly rolling the forefinger, so as to obtain a full impression of its pattern on the side of the thumb.

When searching through a large number of prints that bear the same index number, in order to find a duplicate of a particular specimen, it is a very expeditious method to fix on some one well-marked characteristic of a minute kind, such as an island, or inclosure, or a couple of adjacent bifurcations, that may present itself in any one of the fingers, and in making the search to use a lens or lenses of low power, fixed at the end of an arm, and to confine the attention solely to looking for that one characteristic. The cards on which the finger marks have been made, may then be passed successively under the lens with great rapidity.

[It is proposed to exhibit specimens illustrative of this and of the previous memoir, together with appliances for taking impressions from the fingers, at the approaching *soirée* of the Royal Society.]

Physical Society, May 22.—Prof. W. E. Ayrton, F.R.S., President, in the chair.—Mr. C. J. Woodward exhibited Dr. Schobben's form of lantern stereoscope. This instrument consists of a double lantern, by which the two pictures of a stereoscopic slide are projected on a screen. The two pictures are coloured complementary tints by placing pieces of red and green glass in front of the lenses, and each observer views the overlapping images through spectacles, the eye-glasses of which are also coloured red and green. The stereoscopic effect is very striking. Mr. Boys stated that he had tried to obtain a similar result with the aid of polarized light, by viewing two polarized images through Nicol prisms. No effect was obtained, owing to elliptic polarization produced by the screen, but he thought that if a dead-gold screen had been used instead of an ordinary one, the effect might have been observed.—Prof. Perry, F.R.S., showed a new form of steam-engine indicator. A galvanometer mirror is fixed excentrically to a steel disk, forming one side of a chamber communicating with the cylinder. The pressure of the steam bulges out the disk, and causes the mirror to deflect a ray of light thrown on it in the ordinary way. A rotation of the mirror at right angles to the former is imparted by the movement of the piston-rod. The ray of light traces out the diagram on a screen suitably placed, and the complete figure is continuously visible, owing to the persistence of impressions. This indicator possesses advantages over other forms, in being free from errors due to friction or oscillations of the springs, and the alteration of their elasticity due to temperature changes. The errors of ordinary indicators are considerable at high speeds, owing to the ripples introduced into the indicator diagram. If the natural period of the springs is one-twentieth of the time of a revolution, the diagram is fairly free from ripples, but if it is as much as one-tenth, no amount of friction in the indicator will prevent ripples forming. In the new indicator, the natural period of the disk can be made very short. The steel disks are easily removable, and can be proportioned to suit different pressures and speeds. For experimental and teaching purposes it is advantageous to see at once the alterations in the diagram caused by changes of load, pressure, &c. Several diagrams were exhibited to the meeting. In reply to Prof. Carus Wilson, Prof. Perry stated that the deflection was proportional to the pressure in the cylinder within the limits any particular disk was intended for. Mr. Addenbrooke thought the instrument an important improvement on its predecessors, and considered it would prove of great service to electrical engineers. Mr. Swinburne said a peculiar merit of the indicator was that it could be permanently attached to an engine like an ordinary pressure-gauge. He suggested the use of a small telescope instead of the ray method. The President thought that the instrument could be modified so as to be useful for analyzing the shape of the curves representing alternating currents.—On Blakesley's method of measuring power in transformers, by Prof. Perry, F.R.S. This paper refers to the supposed error in Mr. Blakesley's formula due to the fact that transformers show magnetic leakage. The proofs of the formula hitherto given have been obtained by treating the equations in the manner first adopted by Dr. Hopkinson. On this system the reactions of the primary and secondary currents are represented by the equations—

$$\mathrm{V} = \mathrm{R}_1\mathrm{C}_1 + \mathrm{P}\frac{d\mathrm{N}}{dt}, \quad 0 = \mathrm{R}_2\mathrm{C}_2 + \mathrm{S}\frac{d\mathrm{N}}{dt},$$

where P and N are respectively the turns on the primary and secondary coils, and N is the magnetic flux between the coils. Here it is assumed that there is no magnetic leakage, and the author thinks that on this account the method is inferior to the original method of Maxwell, in which the induced electromotive forces are expressed in terms of coefficients of self and mutual induction. On the assumption that there are no eddy currents, Maxwell's equations are—

$$\mathrm{V} = \mathrm{R}_1\mathrm{C}_1 + \mathrm{L}_1\dot{\mathrm{C}}_1 + \mathrm{M}\dot{\mathrm{C}}_2; \quad 0 = \mathrm{R}_2\mathrm{C}_2 + \mathrm{M}\mathrm{C}_1 + \mathrm{L}_2\dot{\mathrm{C}}_2,$$

in which although L_1, M, and L_2 may not be constant, it may be assumed that they are respectively proportional to P^2, PS, and S^2, if there is no magnetic leakage; and if the amount of magnetic leakage bears a constant proportion to the whole flux, the three quantities may still be assumed proportional to each other, although M^2 is less than L_1L_2. From these equations we obtain

$$\mathrm{VC} = \mathrm{R}_1\mathrm{C}_1{}^2 - \mathrm{R}_2\frac{\mathrm{M}}{\mathrm{L}_2}\mathrm{C}_1\mathrm{C}_2 + \frac{\mathrm{L}_1\mathrm{L}_2 - \mathrm{M}^2}{\mathrm{L}_2}\mathrm{C}_1\dot{\mathrm{C}}_1.$$

Hopkinson puts down the last term as zero, but owing to the very rapid rate at which C_1 changes, the last term is very important, even though M may be but a small percentage less than $\sqrt{L_1L_2}$. On integrating this equation, the first two terms on the right-hand side yield Blakesley's formula, and the last term vanishes in the integral, because, however great the magnetic leakage may be,

$$\int \mathrm{C}_1\dot{\mathrm{C}}_1 dt = 0,$$

when taken over a period because the functions are periodic. Mr. Blakesley's formula thus appears to hold, whatever the magnetic leakage. The paper contains several tables of calculations showing the effect of magnetic leakage on the value of the terms in the equation. Mr. Blakesley said he doubted the correctness of the assumption that the value of M was the same in the two equations, and thought that the result arrived at must be incorrect. Dr. Sumpner did not doubt that if the coefficients could be considered constant, the formula was true whatever the leakage, but he did not consider that the action of transformers justified such an assumption. If the formula were true, it would also hold if there were eddy currents, as these would merely produce the effect of additional secondary coils. He had analyzed Blakesley's method by using a modification of the Hopkinson equations, and had shown that the power as estimated by Blakesley's formula had to be lessened by the fraction represented by the expression

$$\mathrm{X} = \frac{\int x\dot{\mathrm{A}}_p \int \mathrm{A}_s dt dt}{e + \int \mathrm{A}_p\mathrm{A}_s dt},$$

where A_p and A_s are the instantaneous values of the primary and secondary currents, and x is such that $N_p = N_s(1 + x)$ where N_p and N_s are the fluxes of magnetism through the primary and secondary coils at the same instant; e is a negligibly small quantity compared with the rest of the denominator. In obtaining this factor no assumptions whatever had been made, and it was easy to see that if A_p and A_s could be assumed sine functions, and x a constant, the value of the factor X became x simply. In only one case did X reduce to zero, and that was when x was a sine function of the same period as A_p and A_s. He believed that in actual transformers x was approximately constant. Mr. Swinburne pointed out that the split dynamometer was merely a watt-meter, and stated that he had transformers which, owing to magnetic leakage, would indicate an efficiency of over 100 per cent. if tested by Blakesley's method. If this method gives an efficiency of 96 per cent., and leakage causes a drop of 2 per cent. in E.M.F., the real efficiency is only about 94 per cent. He thought that the assumption that the currents followed a sine law was equivalent to supposing that there was no loss in hysteresis. The President said that no one would be more glad than himself to find that Mr. Blakesley's method was accurate, but he could not agree with Prof. Perry that Dr. Hopkinson was wrong in abandoning the academical method of Maxwell. Prof. Perry replied to the various points raised in the discussion.—A paper on current and potential difference analogies in the methods of measuring power, by Prof. W. E. Ayrton and Dr. Sumpner, was postponed.

Royal Microscopical Society, May 20.—Dr. R. Braithwaite, President, in the chair.—The President said he regretted to have to announce the deaths of two of their Honorary Fellows, Dr. Carl von Naegeli, of Munich, and Prof. J. Leidy, of Philadelphia.—Mr. C. L. Curties exhibited a new form of Mayall's mechanical stage, recently manufactured by Zeiss, which gave upwards of an inch motion each way, and merely required to be clamped on the pillar of the microscope when wanted for use.—Mr. Watson exhibited and described a microscope which he had recently made specially to meet the wants of Dr. Van Heurck, of Antwerp. Mr. Mayall, after criticizing the design, for which, he understood, Dr. Van Heurck was responsible, concluded by expressing his regret that Dr. Van Heurck's specification should have resulted in the production of the microscope exhibited. Mr. E. M. Nelson and the Rev. Dr. Dallinger also criticized the instrument adversely.—Mr. Grenfell exhibited the photograph of a small organism, the nature of which he had been as yet unable to determine; some zoologists and botanists to whom he had shown it were unable to say whether it was vegetable or animal in its nature. He also wished to mention that in the Botanical Gardens, Regent's Park, there were considerable numbers of a free-swimming infusorian known as *Tintullus*. It was remarkable for its chitinous lorica.

Claparède mentioned its having been found at Berlin; but hitherto it had only seemed to have been found in sea-water.—Prof. Bell said they had received a communication from Mr. J. B. Rosseter describing the development of *Tænia lanceolata* from the duck, the cysticercoid form of which had not been previously known. He (Mr. Rosseter) had fed the ducks with some of the *Cypris* known to be infested with the parasite, and after some weeks opened the ducks and found the tapeworm mentioned. It was interesting to get the life-history of another tapeworm worked out.—Mr. E. M. Nelson read a note on the subject of lateral development in photography, and a paper on the use of monochromatic light in microscopy, and exhibited the model of a new and simple apparatus for obtaining the same by means of a glass prism. Mr. Nelson also described a new projection microscope fitted with a special condenser made of three flint lenses so as to embrace the whole cone of 82°. The novelty about it was the system of collecting the light, by which a beam of $4\frac{1}{4}$ inches was brought down to $1\frac{1}{4}$ inches, and by passing through two lenses placed in the water-trough, a beam of parallel rays of great intensity was obtained for use in projecting the image upon the screen. Afterwards Mr. Nelson gave an exhibition on the screen.

Geological Society, May 27.—Dr. A. Geikie, F.R.S., President, in the chair.—The following communications were read:—On the lower jaws of *Procoptodon*, by R. Lydekker. After reviewing Sir R. Owen's writings upon the large extinct Kangaroos for which he established the genus *Procoptodon* in 1874, the author describes two mandibular rami from the clay beds of Miall Creek in the neighbourhood of Bingera, N.S.W., which belong to this genus, and from their characters and a comparison of them with the lower jaws in the British Museum, he maintains that this part of the skull indicates two very distinct species of the genus, for which he retains the names *P. rapha*, Ow., and *P. goliah*, Ow., though it is possible that the types of those two species are really specifically identical, in which case the name *P. pusio*, Ow., might have to be adopted for one of the species described.—On some recently exposed sections in the Glacial deposits at Hendon, by Henry Hicks, F.R.S. In this paper the author brings forward evidence obtained from sections exposed in gravel-pits and deep cuttings made for the purpose of laying down the main sewers, to show that Glacial deposits had been spread out to a much wider extent over the Hendon plateau than had hitherto been supposed, and that they had reached down the slopes to below the Ordnance-datum line of 200 feet. He further mentions that there is evidence to show that these deposits have extended in a south and south-west direction across the Brent and Silk Valleys, and now occur on most of the heights in the parishes of Kingsbury and Willesden. As the sands, gravels, and Boulder-clay which cover the Hendon plateau and the neighbouring heights are found to rest on an undulating floor of London Clay, and to follow the contours of the hills and valleys, the author considers that it is clear that the main physical features of this portion of North-west Middlesex were moulded at a very early stage in the Glacial period, and before the so-called Middle sands and gravels and overlying Upper Boulder-clay with Northern erratics were deposited. He believes that at this time there could have been no barrier of any importance to prevent these deposits from extending into the Thames Valley, and that the evidence clearly points to the conclusion that the implement-bearing deposits on the higher horizons in the Thames Valley should be classed as of contemporaneous age with the undoubted Glacial deposits at Hendon, Finchley, and on the slopes of the Brent Valley, which they so closely resemble. The author is therefore satisfied that man lived in the neighbourhood of the Thames Valley in the early part of the Glacial period; probably, he thinks, in pre-Glacial times. This paper led to a discussion, in which Mr. H. B. Woodward, Mr. J. A. Brown, Dr. Hinde, Mr. Monckton, and the author took part.

Entomological Society, June 3.—Mr. Frederick Du Cane-Godman, F.R.S., President, in the chair.—Mr. E. B. Poulton, F.R.S., exhibited living larvæ of *Endromis versicolora*, and commented on their habits.—Mr. W. F. H. Blandford called attention to the fact that the larvæ of *Liparis monacha* remained in small groups on the bark of the tree for about a week after emerging from the eggs, and that this fact was taken advantage of by the German foresters to destroy them. Also that he had himself verified the statement that uric acid can be detected in the Malpighian tubes of insects. Mr. McLachlan, F.R.S., agreed that the demonstration that the Malpighian tubes were of the nature of renal organs was now satisfactory.—Mr. C. J. Gahan exhibited two species of Coleoptera that he considered to possess a mimetic resemblance.—Mr. Tutt exhibited a hybrid between *Amphidasis prodromaria* and *A. betularia*, obtained by Dr. Chapman. Mr. Stainton, F.R.S., commented on the fact that the two insects appeared at different times; and Mr. Tutt stated that the *A. betularia* had been subjected to forcing, so as to cause it to emerge at the same time as *A. prodromaria*.—Mr. Tutt also exhibited forms of *Caradrina*, some of which he said were considered distinct on the Continent, though they were not recognized as such in this country, viz. *Caradrina taraxaci* (*blanda*), *C. superstes*, Tr., from Sligo, and *C. superstes*, H. S., considered as synonymous with *superstes*, Tr., but apparently more closely allied to *C. ambigua*.—Mr. Bristowe exhibited varieties of *Arctia menthastri*, some of which had been fed on mulberry and others on walnut; no difference was observed in the variation.—Mr. G. Elisha exhibited larvæ in their cases of *Coleophora vibicigerella* and *C. maritimella*.—Mr. A. G. Butler communicated a paper entitled "Additional Notes on the Synonymy of the Genera of Noctuid Moths."

Zoological Society, June 2.—Prof. W. H. Flower, C.B., F.R.S., President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of May 1891, calling special attention to a female Water-buck Antelope (*Cobus ellipsiprymnus*) from British East Africa, presented by Mr. George S. Mackenzie, and to three Blanford's Rats (*Mus blanfordi*) from Kadapa, Madras, received in exchange, new to the collection.—Mr. Sclater made some remarks on the animals which he had noticed during a recent visit to the Zoological Gardens of Paris, Ghent, Antwerp, Rotterdam, Amsterdam, and the Hague.—Prof. Newton, F.R.S., exhibited (on behalf of Prof. Stirling, of the University of Adelaide), a drawing, being the first received in Europe, representing the remarkable new Australian Mammal lately described by Prof. Stirling as *Notoryctes typhlops*, which was stated to be the Mole-type of the order Marsupialia.—The Secretary exhibited (on behalf of Mr. F. E. Blaauw) specimens of the Long-tailed Tit, shot in Holland, and sent to this country for the purpose of ascertaining whether they belonged to the British form (*Acredula rosea*) or the white-headed Continental form (*A. caudata*).—Mr. F. Finn exhibited a hybrid Duck bred in the Society's Gardens, believed to be bred between a male Chilian Pintail (*Dafila spinicauda*) and a female Summer-Duck (*Æx sponsa*).—A communication was read from Dr. O. F. von Moellendorff containing a revised list of the Land and Freshwater Shells of Perak, with descriptions of some new species.—A communication was read from Dr. G. E. Dobson, F.R.S., containing a sketch of the derivation and distribution of the Mammals of the order Insectivora found in the New World.—Mr. G. A. Boulenger read a report on Reptiles, Batrachians, and Fishes of which specimens had been collected for the West Indian Exploration Committee in some of the Lesser Antilles, and deposited in the British Museum.—A communication was read from Mr. Hamilton H. Druce containing an account of the Butterflies of the family Lycænidæ obtained by Mr. C. M. Woodford in the Solomon Islands.

CAMBRIDGE.

Philosophical Society, May 18.—Prof. Liveing, Vice-President, in the chair.—The following communications were made:—On parasitic Mollusca, by Mr. A. H. Cooke.—Mr. W. Bateson exhibited and explained models of double supernumerary appendages in insects; and also a mechanical method of demonstrating the system upon which the symmetry of such appendages is usually arranged.—On the nature of the excretory processes in marine Polyzoa, by Mr. S. F. Harmer. This communication was the result of an occupation of a University table at the Zoological Station at Naples during the Easter Vacation of 1891. Observations were made on the manner in which various artificial pigments were excreted in *Bugula* and in *Flustra*, on the lines adopted by Kowalevsky (*Biolog. Centralblatt*, ix., 1889–1890, pp. 33, &c.) for other invertebrates. The general result of the experiments was to show that excretion is not performed by organs comparable with nephridia, but that this process is carried on by free mesoderm cells, and to some extent by the connective tissue and by the walls of the alimentary canal. Evidence was obtained to show that the periodic loss of the alimentary canals leading to the formation of the "brown bodies" may be regarded as, to some extent, an excretory process.

Paris.

Academy of Sciences, June 1.—M. Duchartre in the chair.—Calorimetric researches on humic acid derived from sugar, by MM. Berthelot and André. The experiments show that humic acid is a polybasic acid which may be caused to unite with three equivalents of potash to form insoluble salts : one salt described is monobasic, stable, and formed with the evolution of 18 calories, an amount comparable with that evolved when alkaline salts are formed by the action of strong acids. Many other properties of this acid are given.—Analysis of the light diffused by the sky, by M. A. Crova. The observations recorded extend from December 1889 to the same month in 1890. From the results it appears that the blue colour of the sky is most intense in the months of December, January, March, and September; and shows minima in July, August, and November. Roughly, the blue colour is deepest in the winter, and palest in summer; spring and autumn give sensibly the same results. A comparison of the intensities at different hours of the day indicates that a maximum blue coloration occurs in the morning and a minimum at the hottest hour in the day.—On Abelian equations, by M. A. Pellet.—On a new method of determining the vertical motion of aërostats, by M. André Duboin. The methods usually employed by balloonists to determine their state of vertical motion are by means of a barometer, or by throwing out light bits of paper and observing whether they ascend or descend relatively to the balloon. The author has devised an apparatus having the same object, on the principal of Kretz's differential manometer, and claims for it a sensibility 150 times greater than the ordinary mercurial barometer.—New models of copper oxide batteries, by M. F. de Lalande. A 35 per cent. solution of potash is the liquid employed. In it dips a conglomerate of copper oxide and sand covered with a thin porous layer of metallic copper, and one or two zinc plates. A cell thus constituted is shown to be practically constant for three or four days, and is said to work for years without getting out of order.—Determination of molecular weights at the critical point, by M. Philippe A. Guye. Using Van der Waals's formula, the author deduces $d = 1146\dfrac{\delta\theta}{\pi(1670 + \theta)}$, where d is the critical density with respect to air, δ the critical density with respect to water—that is, the weight of the substance in grams occupying a volume of one cubic centimetre at the critical state—θ the absolute temperature, and π the pressure in atmospheres. It is then shown that the values of d obtained by means of this empirical formula are equal to the molecular weights of the substances investigated divided by 28·87.—Research on the separation of metals from platinum, and in particular of palladium and rhodium in the presence of common metals, by MM. A. Joly and E. Leidié. The platinum or palladium are converted into soluble nitrites by the addition of potassium nitrite, and are thus separated from other metals.—On the specific heats of some solutions, by M. W. Timofeiew. Alcoholic solutions of bichloride of mercury and cadmium iodide were used. It is shown that the difference between the molecular specific heat of the solution and solvent is sensibly equal in the case of both salts, the mean value being 52. Taking this value to represent the molecular specific heat of the salt in solution and the specific heats of the alcohols employed to be expressed by the formulæ,

$C^{\text{methyl}} = 0{\cdot}56755 + 0{\cdot}001633t$; $C^{\text{ethyl}} = 0{\cdot}53574 + 0{\cdot}002132t$;

it is shown that the observed and calculated specific heats of the solutions are very nearly the same in each case.—On the oxidation products of uric acid, by M. C. Matignon. The heats of formation and combustion of the principal derivatives of uric acid are considered.—On the employment of ammonium selenite for the identification of alkaloids, by M. A. J. Ferreira da Silva. The use of ammonium sulphoselenite for the detection of morphine and codeine was suggested by M. Lafon in 1885. The author shows how the method can be extended to other alkaloids.—On the development of the liver of Nudibranchiates, by M. H. Fischer. The research shows that the liver of Nudibranchiates is formed to a great extent by the left hepatic lobe of the embryo, and that the hepatic organs in two very different groups of Mollusca, the Lamellibranchiates and Nudibranchiates, are homologous productions.—The *Isaria*, a parasite of the larva of the cockchafer, by M. Alfred Giard.—The genera of the group of Clusia, and in particular the genus *Tovomita*, by M. J. Vesque.—On some supporting elements of the leaves of Dicotyledons, by M. E. Pée-Laby.—Diffusion of three distinct forms of titanium oxide in the Cretaceous strata of Northern France, by M. L. Cayeux. A microscopic examination of the residue after treating chalk with an acid leads the author to believe he has recognized the three crystalline forms of titanium oxide—rutile, anatase, and brookite.—The lichens on mulberry-trees, and their influence on silk culture, by M. G. Hallauer.—On the employment of carbon bisulphide against aërial parasites, by M. H. Quantin.

Amsterdam.

Royal Academy of Sciences, May 30.—Prof. Van de Sande Bakhuyzen in the chair.—Dr. Bakhuis Roozeboom treated of the solubility of mixed crystals of isomorphous substances. Admitting the absolute homogeneity of such crystals, according to the recent researches of Retgers, it is possible to deduce, by thermodynamical reasoning, that, when p and T are taken as constants, equilibrium is obtained when to a proportion α of the components in the mixed crystals, correspond two definite values C_1 and C_2 for the concentrations of the components in the aqueous solution. From the analogy between the said equilibrium and that between a liquid and a gaseous phase, composed of two substances, are further deduced some general conclusions as to the behaviour of solutions of two isomorphous salts when they are evaporated. This is done both for the case in which the mixed crystals form a continuate series, and that in which they present a hiatus. The latter was found in studying the solubility of $KClO_3$ and $TlClO_3$. Solid mixtures were obtained at 10° and 1 atm. from 0-36·3 and from 97·9-100 per cent. $KClO_3$. In the evaporation of any one solution, it tends to a composition, which is necessary to deposit the two kinds of crystals between which the hiatus exists.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Bacteria and their Products: Dr. Sims Woodhead (Scott).—Einleitung in die Theoretische Physik; Zweite umg. und verm. auflage: V. von Lang (Braunschweig, Viewig).—A Manual of Forestry, vol. ii.: Dr. W. Schlich (Bradbury).—The British Noctuæ and their Varieties, vol. i.: J. W. Tutt (Sonnenschein).—Practical Work in Organic Chemistry: P. W. Streatfeild (Spon).—Katalog der Bibliothek der Deutschen Seewarte zu Hamburg (Hamburg).—Catalogue of the Fossil Birds in the British Museum (Natural History): R. Lydekker (London).—The Solar Parallax and its Related Constants; W. Harkness (Washington).—Favourite Foreign Birds: W. T. Greene (Gill).—Anthropogeographie: Dr. F. Ratzel (Stuttgart, Engelhorn).—Notes on Building Construction, Part 2, new edition (Longmans).—Poachers and Poaching: J. Watson (Hall).—Modern Cremation, 2nd edition: Sir Henry Thompson (Paul).—Nature and Treatment of Diphtheria, 3rd edition: R. W. Parker (Lewis).—Riddles of the Sphinx: A Troglodyte (Sonnenschein).—Housing of the Poor: F. H. Millington (Cassell).—British Cage-Birds, Part 14: R. L. Wallace (Gill).—A Manual of Orchidaceous Plants, Part 7 (Veitch).—Tasmanian Official Record, 1891 (Hobart).—The Birds of Manitoba: E. E. Thompson (Washington).—Scientific Results of the Second Yarkand Mission; Coleoptera (Calcutta).—Smithsonian Report, 1889 (Washington).—Internationales Archiv für Ethnographie, Band 4, Heft 3 (Paul).—The Asclepiad, No. 30, vol. viii.: B. W. Richardson (Longmans).—Photographic Reporter, June (Hazell).

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